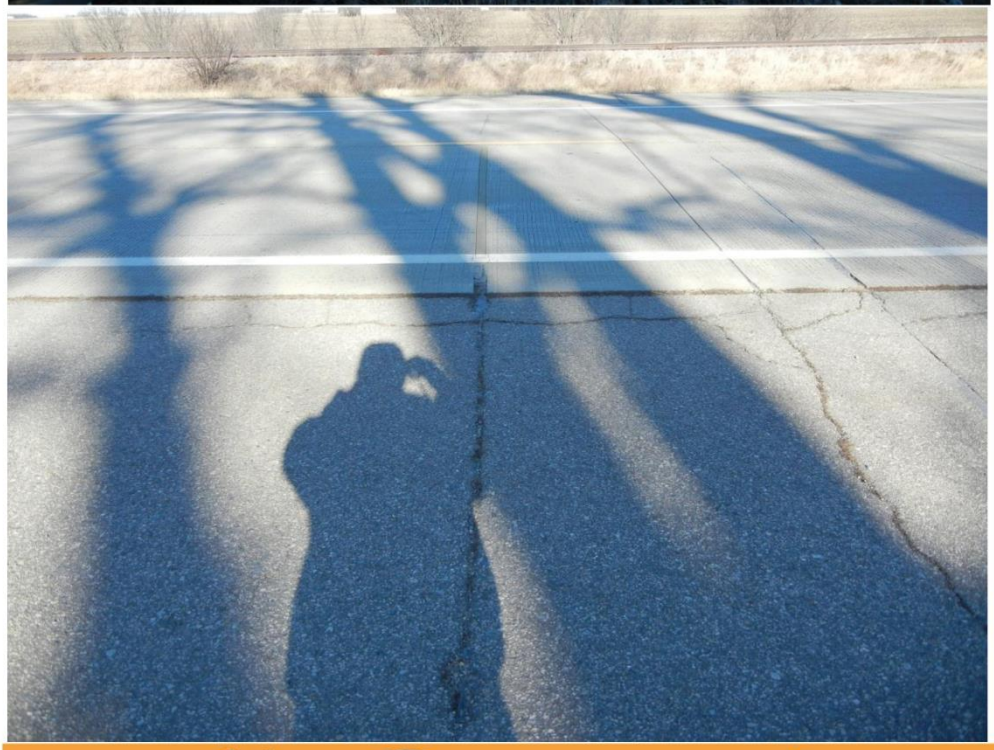
SEPTEMBER 2019



WIM #33
US 212, MP 78.5
OLIVIA, MN

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #33 is located on US 212 near Olivia in Renville county.

System Operation

WIM #33 was operational for the entire month of September 2019. Volume was computed using all monthly data.

System Calibration

WIM #33 was most recently calibrated on 2015-06-17. Table 1 summarizes the front axle weights of class 9s by lane [1]. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 152884 | Passenger Vehicles: 129490 | Heavy Commercial Vehicles: 23394

Monthly Average Daily Traffic (MADT): 5138 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 780

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. EB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Saturdays. WB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Sundays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), EB PVs generally reached peak volume levels between 03 PM and 05 PM. Similarly, WB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling EB typically reached peak volume levels between 03 PM and 05 PM, while volume going WB peaked between 03 PM and 05 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 23394 HCVs, 2129 of them were overweight [3]. These overweight HCVs contributed to 1.4% of total monthly volume, and 9.2% of total monthly

HCV volume. EB overweight vehicles typically reached highest numbers on Wednesdays, with lowest volumes reported on Saturdays. WB overweight vehicles tended to reach highest volumes on Saturdays, with lowest volumes reported on Thursdays. See Figure 3 . The top two overweight violators by class were the class 13 and class 9 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 54.8% of all overweight vehicles traveling WB this month (see Figure 7 & 8). Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in January.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,141 EB vehicles exceeded 88,000 pounds (121 vehicles were Class 13's; 16 vehicles were Class 10's). Of vehicles traveling WB,

156 EB vehicles exceeded 88,000 pounds (150 vehicles were Class 13's; 4 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from September 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in September 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling EB, while there were more empty Class 9's than fully_loaded traveling WB. Data also suggests that there were more empty Class 10's than fully_loaded traveling in the EB direction. In the WB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 203283 tons of freight was recorded to have crossed the WIM. More freight was shipped WB (51.6%) than EB (48.4%). See Table 4 and Figure 11 for more freight information.

####**Infrastructure Considerations Bridge.** Bridge No. 6299 (a box culvert) is approximately 13.4 miles east of WIM #33, and Bridge No. 96640 (a box culvert) is 2.5 miles west of WIM #33. WIM #33 recorded a total of 152884 vehicles with a combined GVW of 1628037 kips (1 kip = 1,000 pounds = 0.5 tons) in September 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 14690 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 55.9% of all ESALs were recorded EB while 44.1% was observed WB. In particular, 70% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 41% of total GVW observed this month). See Table 6 and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

#####WIM monthly reports can be found at:
http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html MnDOT's vehicle

classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

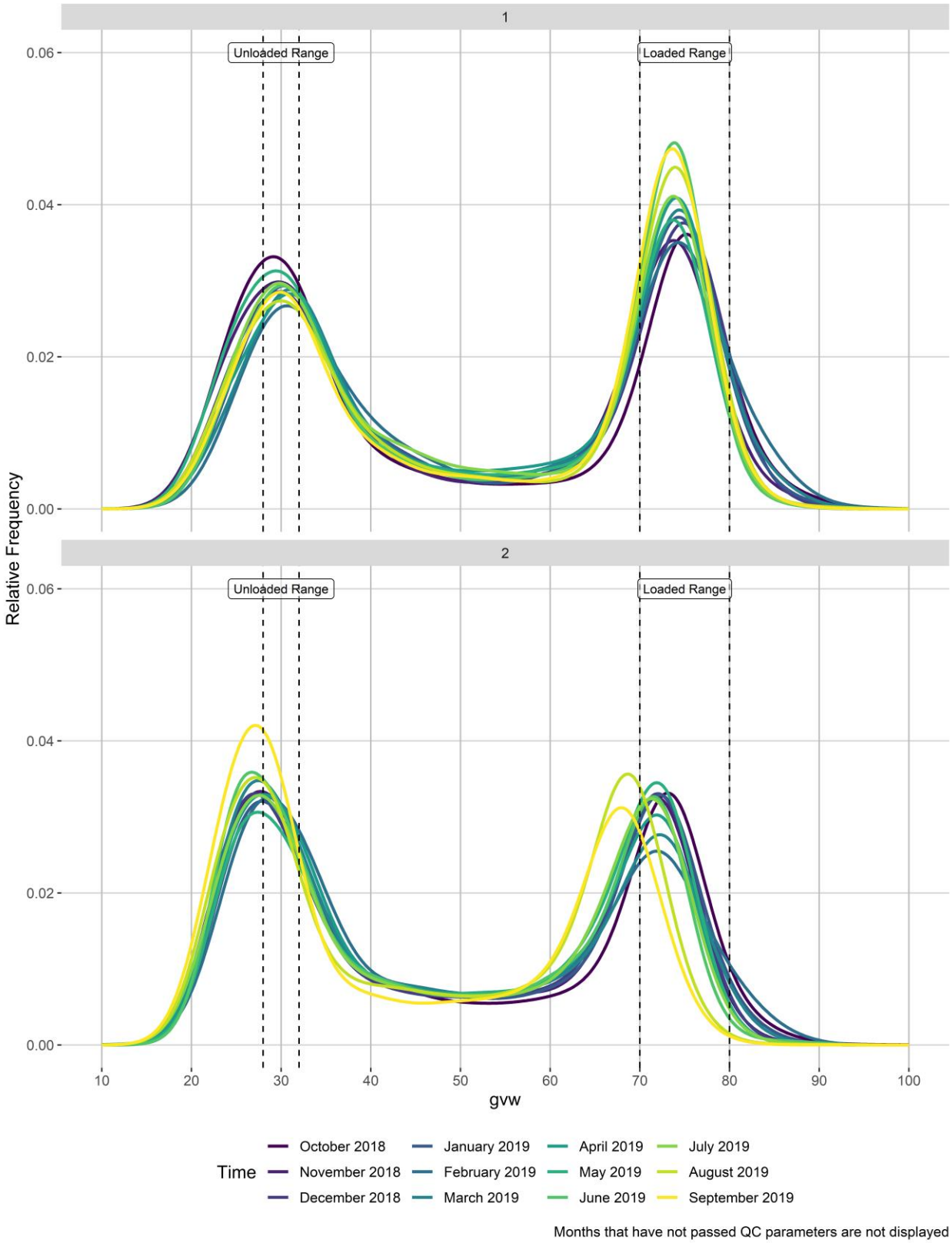
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

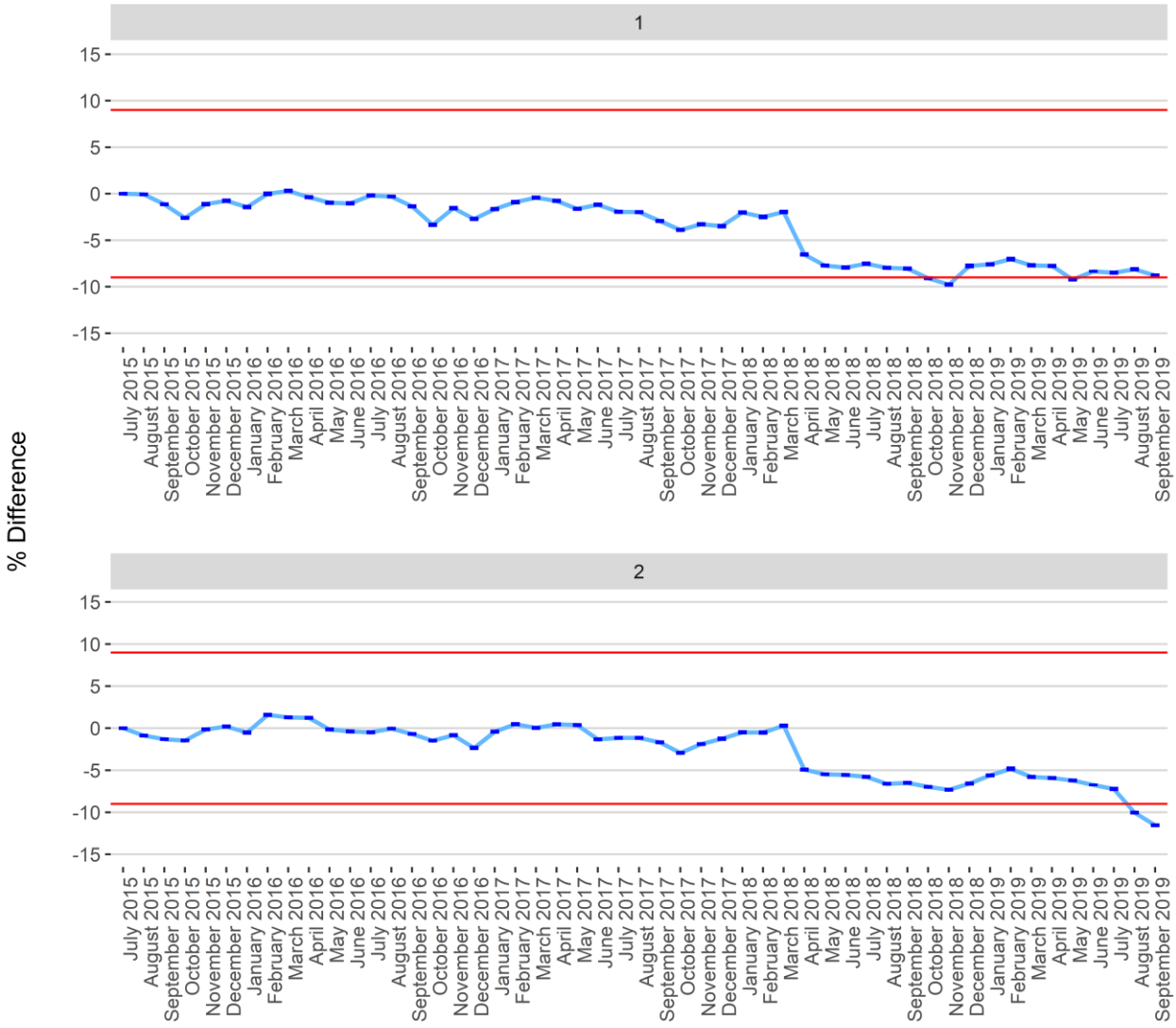
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume
vs. Day of the Week

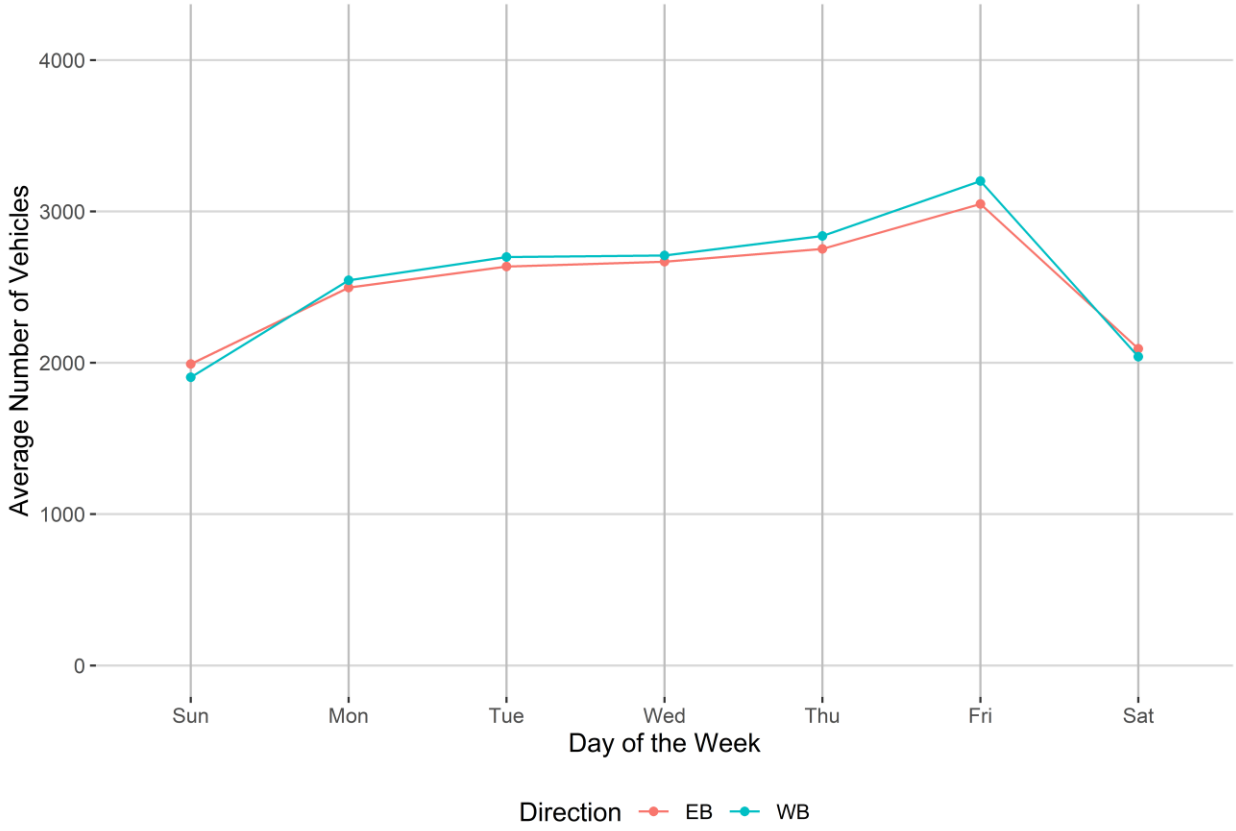


Figure 3 - Average Overweight Vehicle Volume
vs. Day of the Week

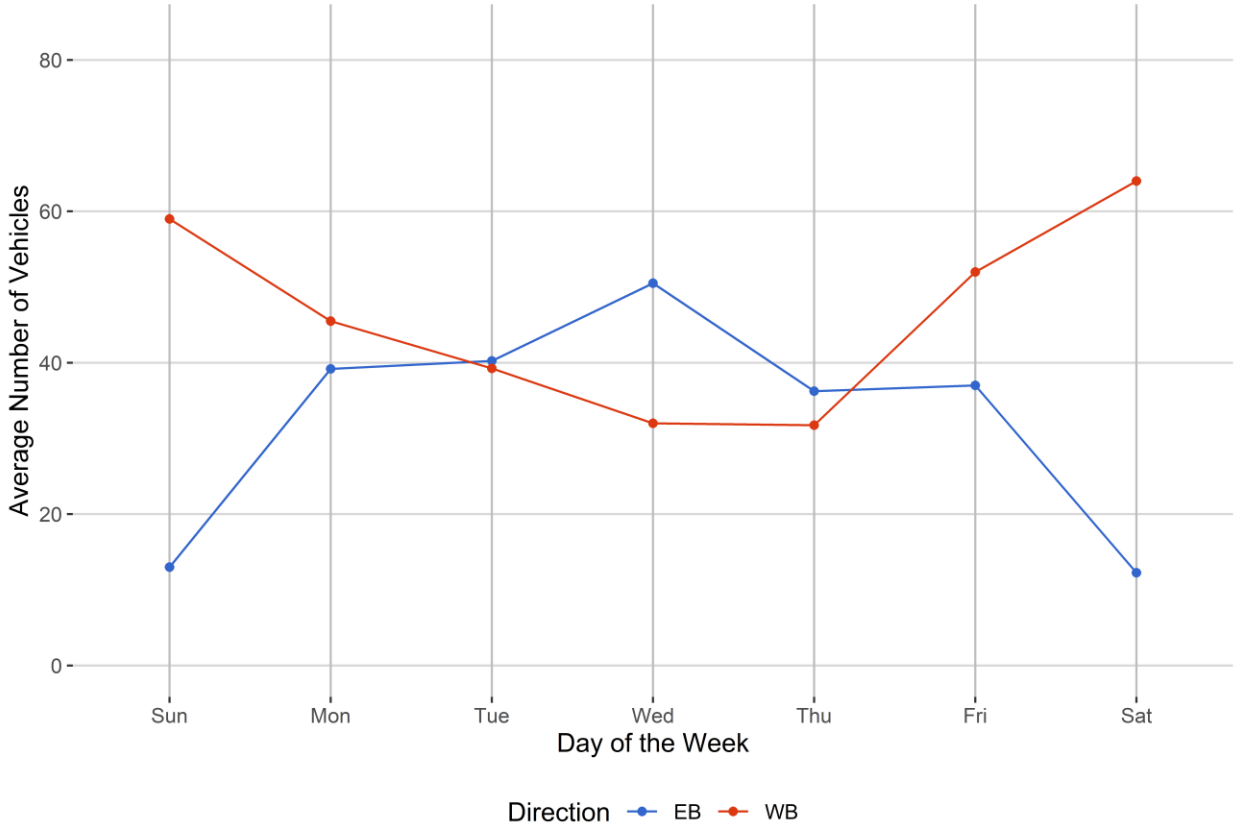


Figure 4 - Passenger Vehicles
vs. Hour of the Day

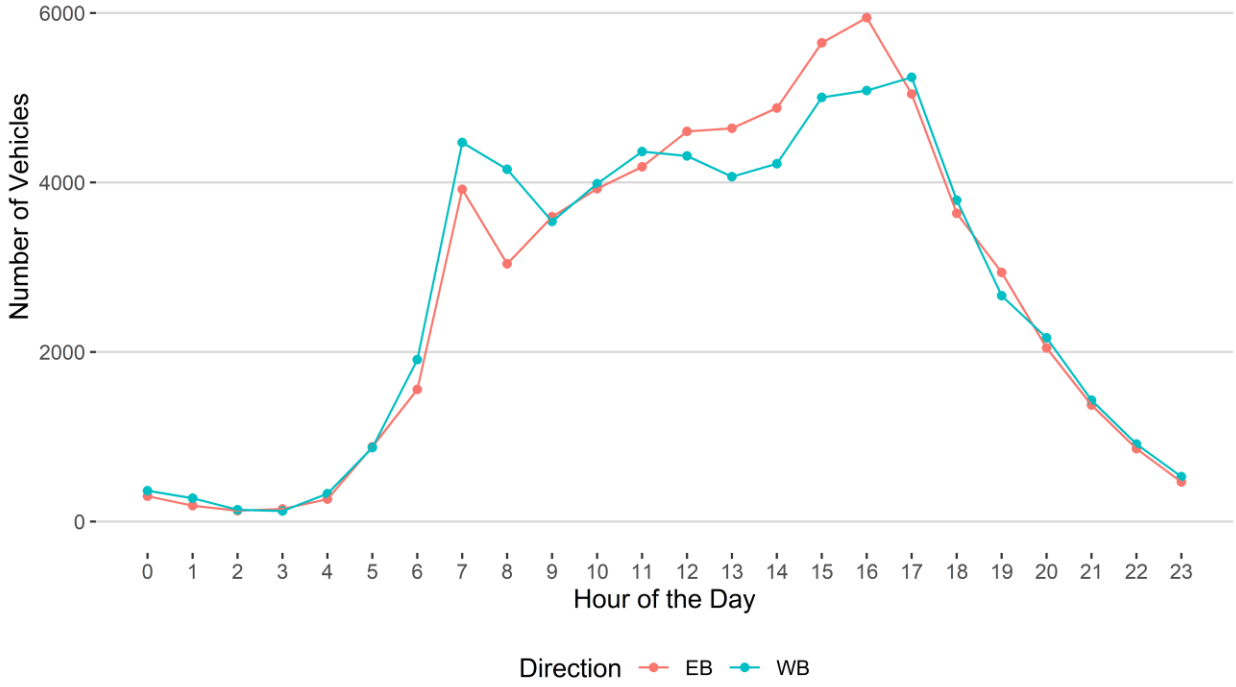


Figure 5 - Heavy Commercial Vehicles
vs. Hour of the Day

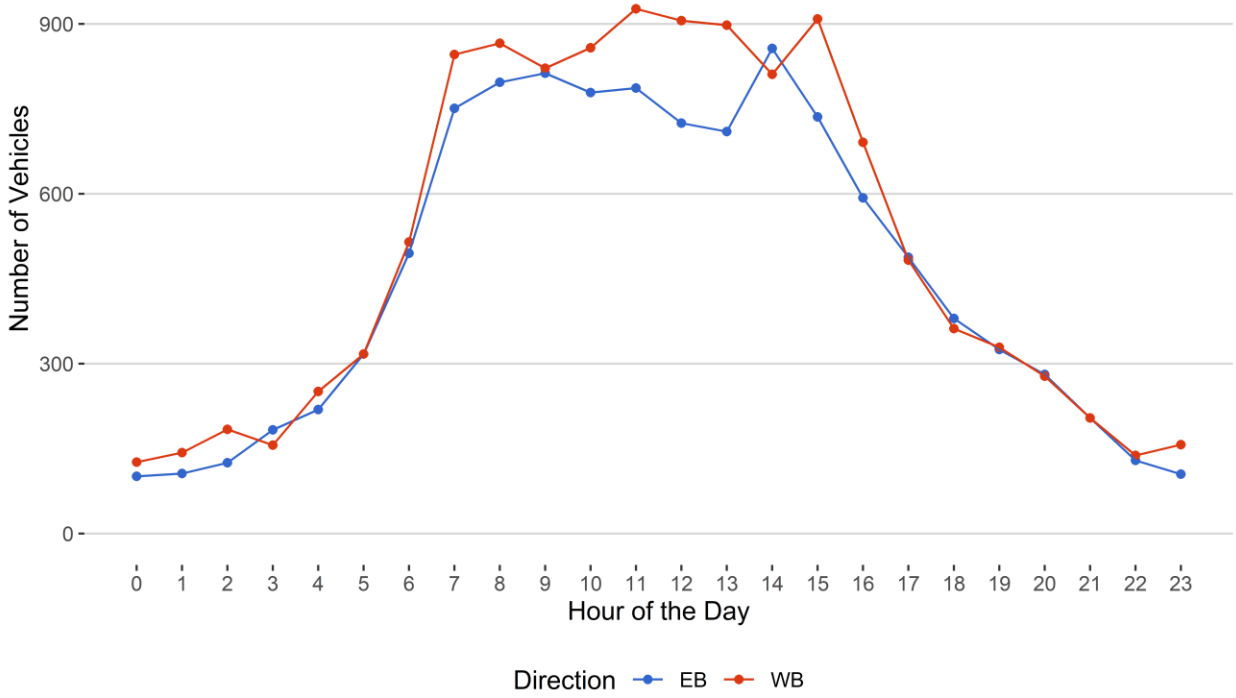


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

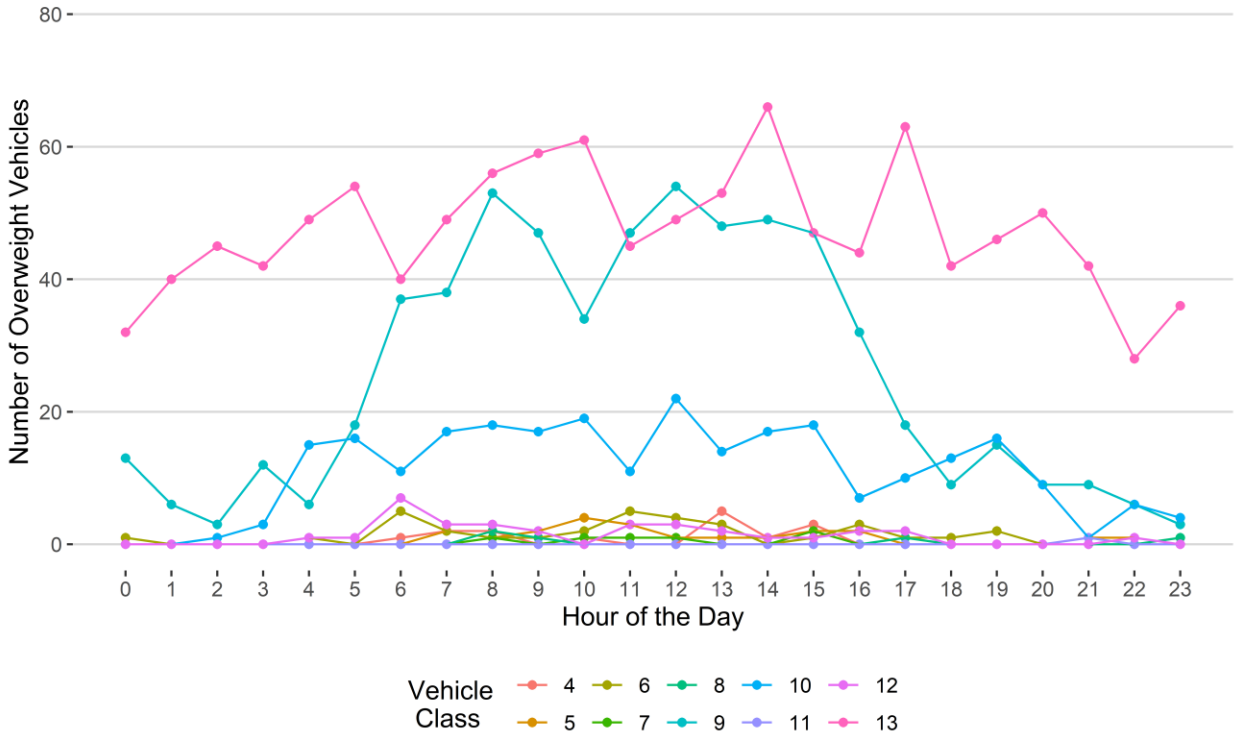


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

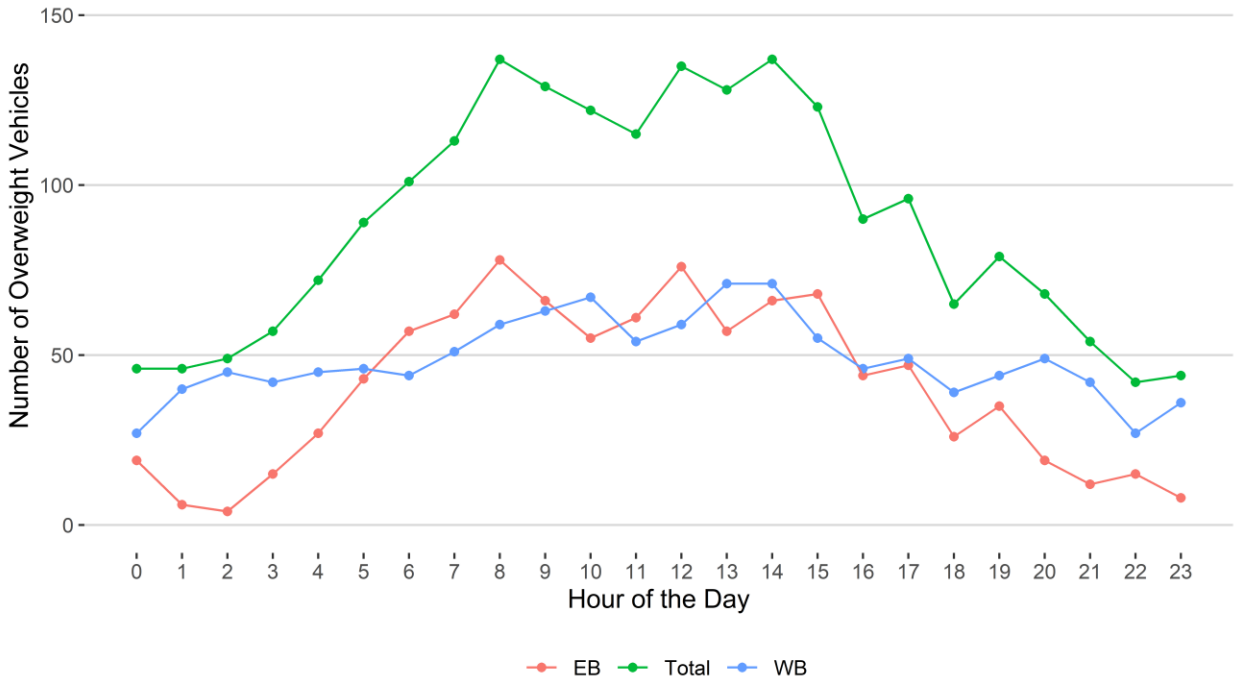
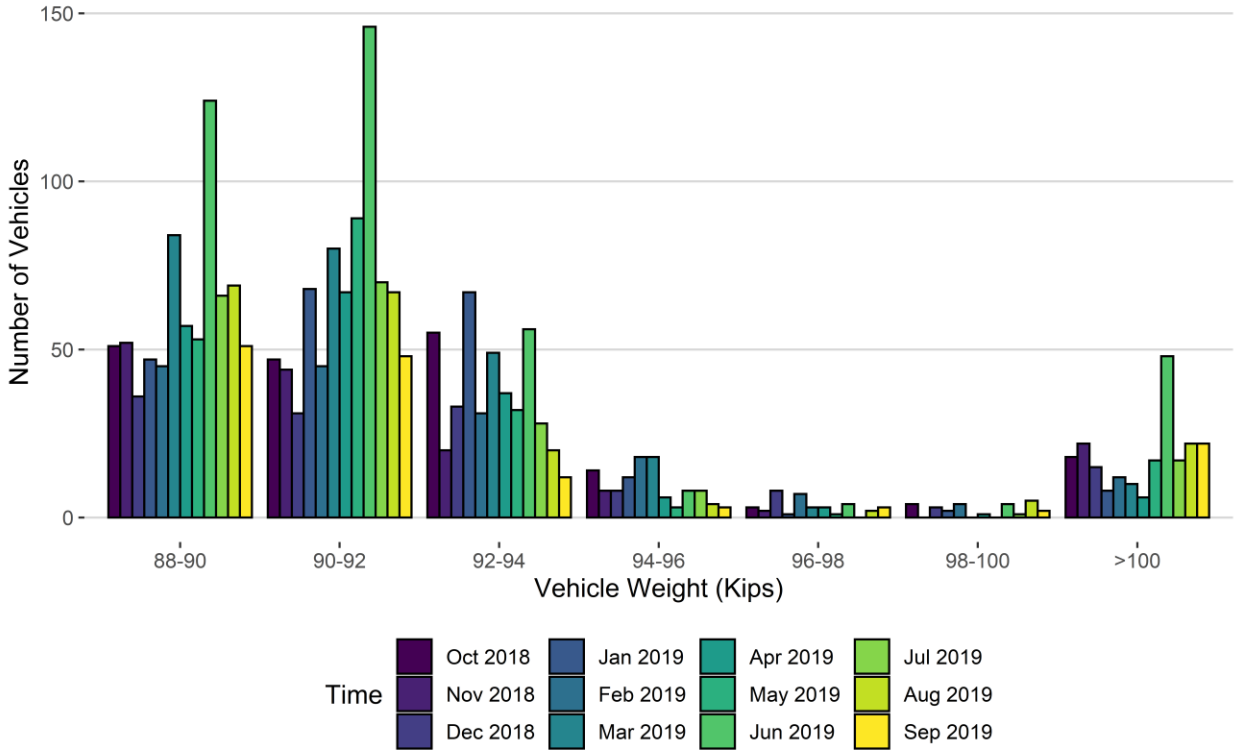
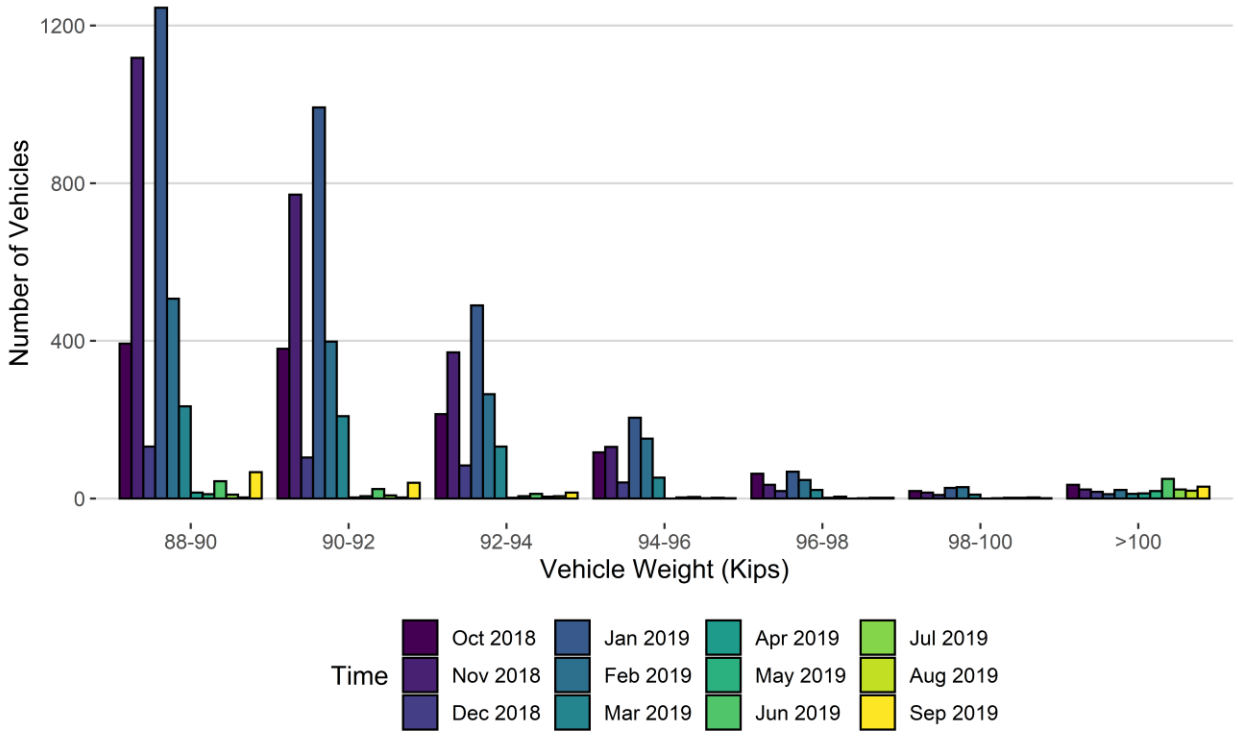


Figure 8 - Histogram of EB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*
88-90	51	52	36	47	45	84	57	53	124	66	69	51
90-92	47	44	31	68	45	80	67	89	146	70	67	48
92-94	55	20	33	67	31	49	37	32	56	28	20	12
94-96	14	8	8	12	18	18	6	3	8	8	4	3
96-98	3	2	8	1	7	3	3	1	4	0	2	3
98-100	4	0	3	2	4	0	1	0	4	1	5	2
>100	18	22	15	8	12	10	6	17	48	17	22	22
Total	192	148	134	205	162	244	177	195	390	190	189	141

Figure 8 - Histogram of WB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*
88-90	393	1118	132	1245	507	234	15	11	44	10	3	67
90-92	380	771	104	992	398	209	3	6	24	8	3	40
92-94	214	371	84	490	265	132	2	6	12	5	6	15
94-96	117	131	41	205	152	53	0	3	4	1	2	1
96-98	63	35	19	68	47	22	2	5	0	1	2	2
98-100	19	15	9	27	29	10	0	1	2	2	3	1
>100	35	23	17	11	22	12	13	19	50	23	20	30
Total	1221	2464	406	3038	1420	672	35	51	136	50	39	156

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

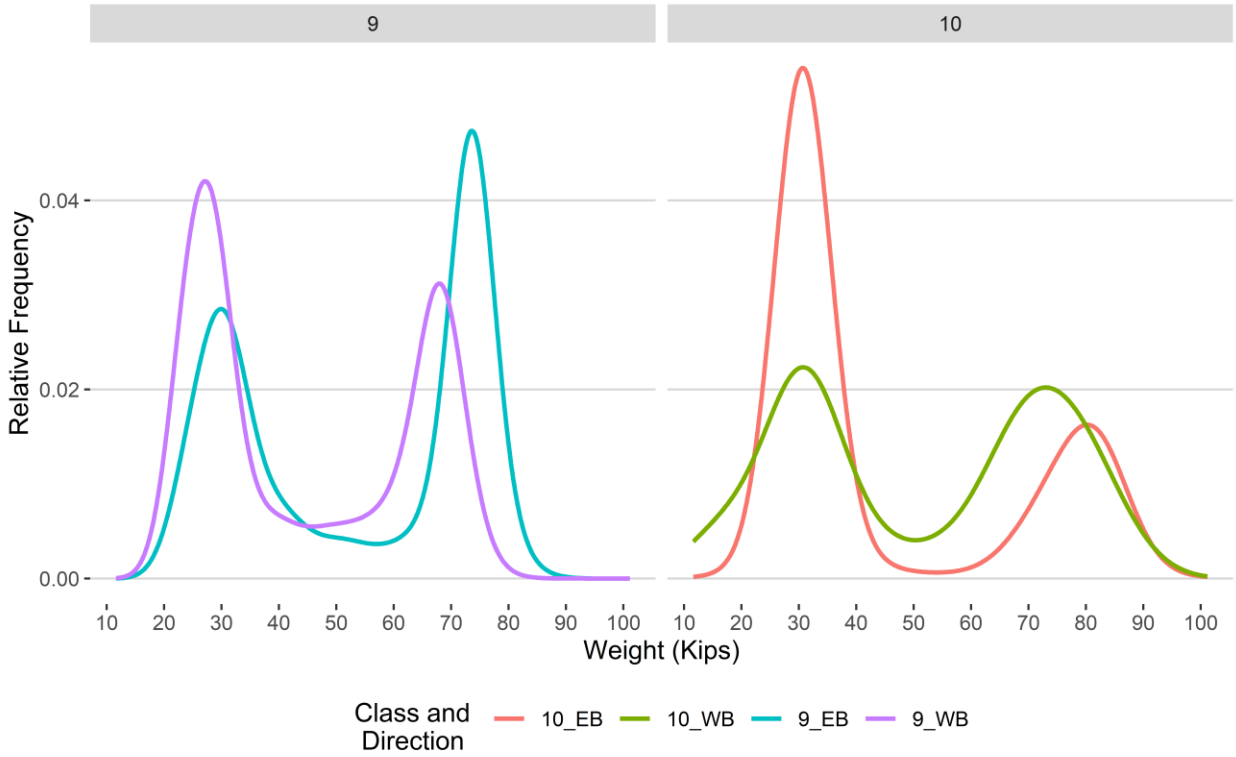


Figure 9 - Freight Percentage by Direction and Class

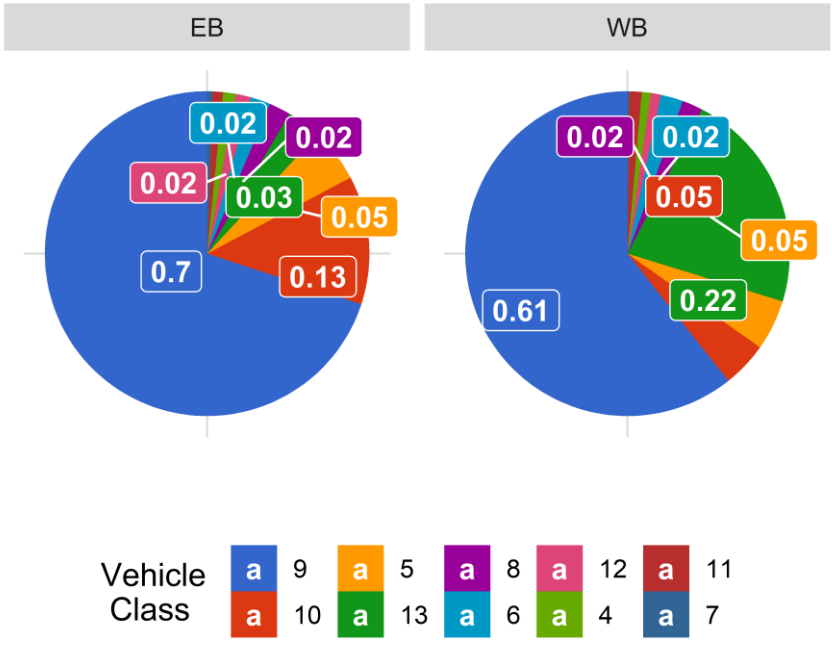


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

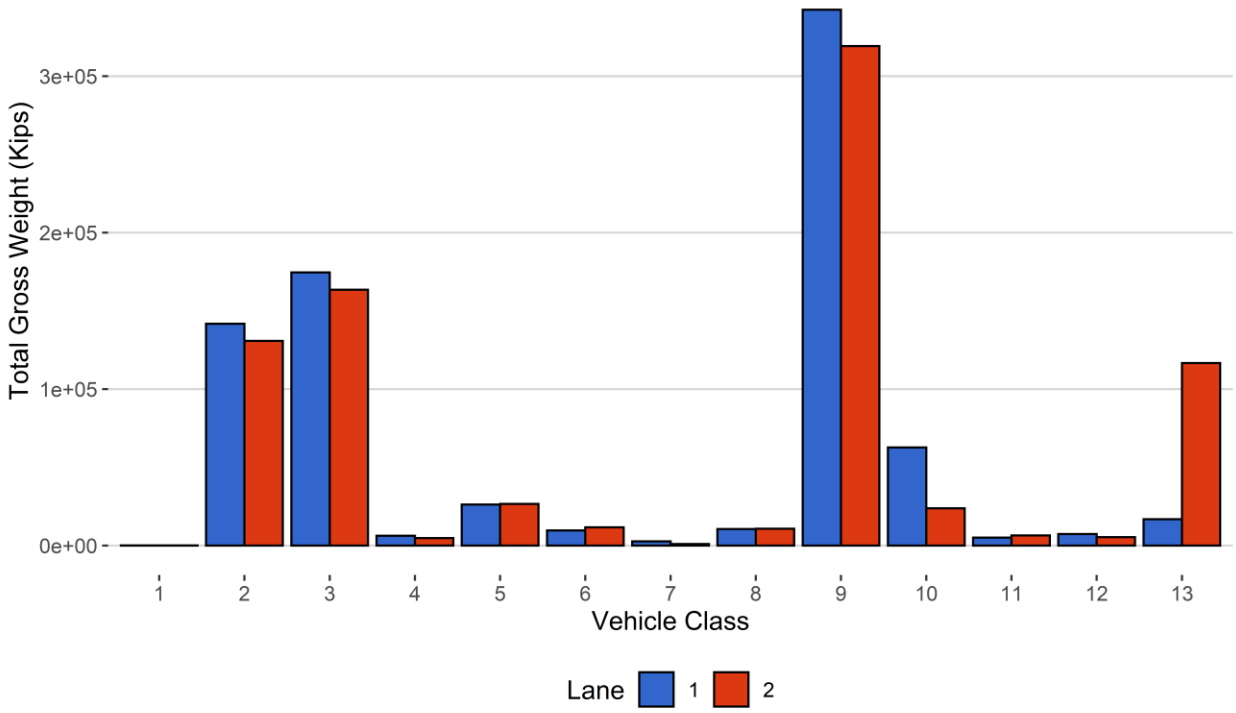


Figure 11 - Total Gross Vehicle Weight b

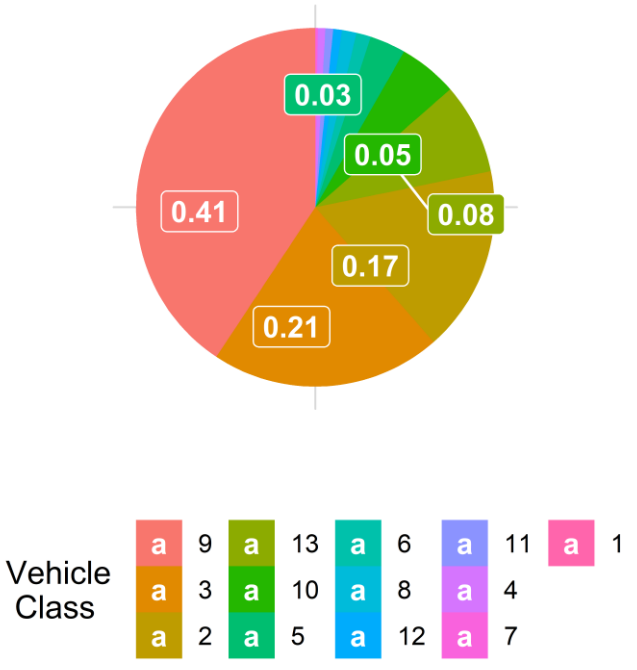


Figure 12 - Total ESALs by Class and Lane

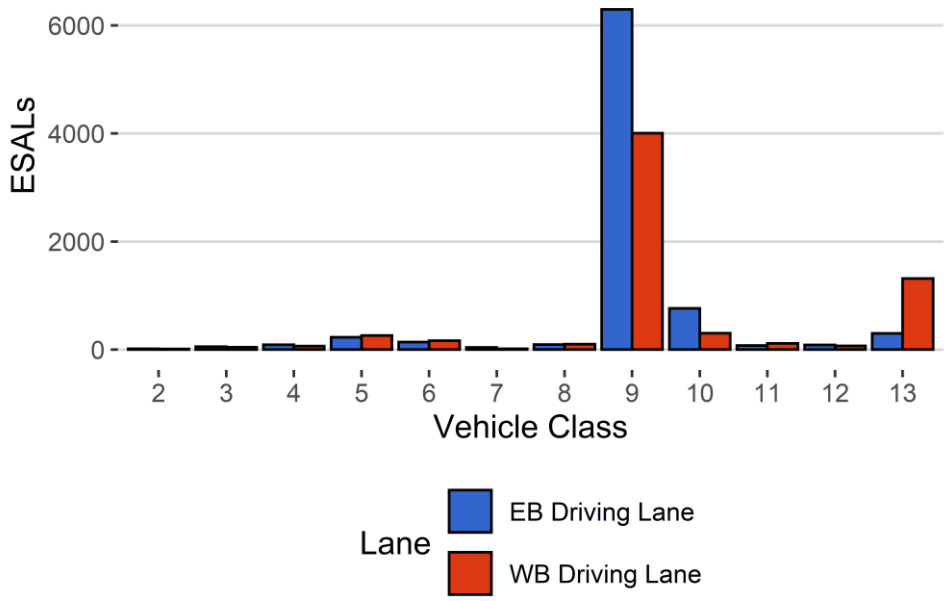


Figure 13 - ESALs by Class

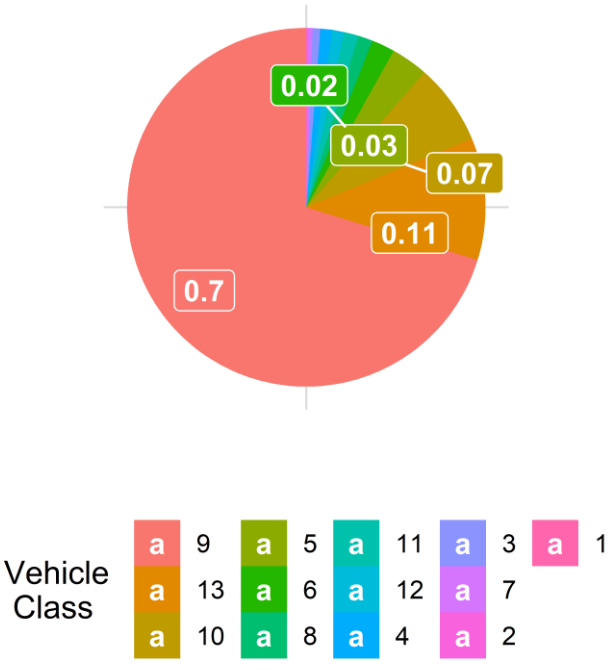


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*
July 2015	11.76	0.00	10.98	0.00
August 2015	11.75	-0.07	10.89	-0.88
September 2015	11.62	-1.13	10.84	-1.31
October 2015	11.45	-2.60	10.82	-1.46
November 2015	11.63	-1.12	10.97	-0.15
December 2015	11.67	-0.76	11.00	0.20
January 2016	11.59	-1.44	10.92	-0.53
February 2016	11.76	-0.01	11.16	1.58
March 2016	11.79	0.31	11.12	1.28
April 2016	11.71	-0.37	11.12	1.23
May 2016	11.64	-0.97	10.97	-0.15
June 2016	11.64	-1.04	10.94	-0.39
July 2016	11.74	-0.19	10.93	-0.49
August 2016	11.72	-0.31	10.98	-0.05
September 2016	11.60	-1.36	10.91	-0.69
October 2016	11.36	-3.35	10.82	-1.48
November 2016	11.58	-1.55	10.89	-0.83
December 2016	11.44	-2.72	10.72	-2.35
January 2017	11.56	-1.65	10.94	-0.41
February 2017	11.65	-0.91	11.03	0.47
March 2017	11.71	-0.43	10.99	0.03
April 2017	11.67	-0.77	11.03	0.46
May 2017	11.57	-1.63	11.02	0.37
June 2017	11.62	-1.18	10.84	-1.33
July 2017	11.53	-1.94	10.86	-1.15
August 2017	11.53	-1.98	10.86	-1.15
September 2017	11.41	-2.94	10.80	-1.68
October 2017	11.30	-3.90	10.66	-2.94
November 2017	11.37	-3.28	10.77	-1.89
December 2017	11.35	-3.49	10.84	-1.26
January 2018	11.52	-2.02	10.93	-0.49
February 2018	11.46	-2.50	10.93	-0.52
March 2018	11.53	-1.97	11.02	0.30
April 2018	10.99	-6.53	10.44	-4.92
May 2018	10.85	-7.73	10.38	-5.48
June 2018	10.82	-7.93	10.37	-5.55
July 2018	10.87	-7.53	10.35	-5.78
August 2018	10.82	-7.97	10.26	-6.62
September 2018	10.81	-8.05	10.27	-6.50

October 2018	10.69	-9.08	10.22	-6.98
November 2018	10.61	-9.77	10.18	-7.32
December 2018	10.84	-7.77	10.26	-6.58
January 2019	10.86	-7.59	10.37	-5.61
February 2019	10.93	-7.03	10.45	-4.83
March 2019	10.85	-7.70	10.35	-5.79
April 2019	10.84	-7.77	10.33	-5.92
May 2019	10.67	-9.22	10.30	-6.22
June 2019	10.78	-8.35	10.24	-6.74
July 2019	10.76	-8.49	10.19	-7.23
August 2019	10.80	-8.12	9.88	-10.04
September 2019	10.72	-8.79	9.71	-11.55

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	2	46	0	0	0
2	2369	71071	46.5	0	0
3	1946	58373	38.2	0	0
4	14	432	0.3	15	0.7
5	129	3859	2.5	21	1
6	26	780	0.5	33	1.6
7	2	71	0	6	0.3
8	26	768	0.5	5	0.2
9	452	13560	8.9	613	28.8
10	62	1853	1.2	265	12.4
11	8	234	0.2	1	0
12	7	215	0.1	32	1.5
13	54	1623	1.1	1138	53.5
TOTAL	**5096**	**152884**	**100**	**2129**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-09-11	Wednesday	14:23:31	9	EB	1	118.76
2019-09-27	Friday	15:38:36	10	EB	1	101.15
2019-09-05	Thursday	06:58:44	10	EB	1	96.72
2019-09-18	Wednesday	12:54:08	10	EB	1	93.97
2019-09-22	Sunday	05:01:39	10	WB	2	91.9
2019-09-10	Tuesday	11:20:21	9	WB	2	91.58
2019-09-30	Monday	15:48:33	10	WB	2	91.21
2019-09-20	Friday	07:00:26	10	WB	2	90.88
2019-09-18	Wednesday	18:15:03	10	EB	1	90.58
2019-09-13	Friday	18:31:30	10	EB	1	90.57

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	EB	15	237	28	11.8	5905	354	1385
5	EB	8	1857	238	12.8	24417	1749	5732
6	EB	19	354	95	26.8	8070	1597	1574
7	EB	11.5	48	2	4.2	2594	17	1033
8	EB	31	374	242	64.7	4907	5604	407
9	EB	33	6326	1879	29.7	289439	53012	71344
10	EB	33.5	1377	897	65.1	35319	27305	9619
11	EB	36.5	113	40	35.4	3800	1261	568
12	EB	36.5	128	4	3.1	7234	138	1354
13	EB	31.5	192	4	2.1	16645	119	5361
TOTAL	****	****	**11006**	**3429**	****	**398329**	****	**98378**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	WB	15	191	45	23.6	4194	584	1002
5	WB	8	1967	367	18.7	23933	2637	5566
6	WB	19	419	106	25.3	9942	1708	1997
7	WB	11.5	22	0	0	949	0	348
8	WB	31	387	246	63.6	5223	5517	426
9	WB	33	7112	3305	46.5	230862	88368	52616
10	WB	33.5	459	172	37.5	19130	4659	4758
11	WB	36.5	119	3	2.5	6338	71	1052
12	WB	36.5	85	2	2.4	5316	71	1143
13	WB	31.5	1416	0	0	116598	0	35997
TOTAL	****	****	**12177**	**4246**	****	**422484**	****	**104905**
GRAND TOTAL	****	****	**23183**	**7675**	**476**	**820813**	**194770**	**203283**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*
1	41	21	62	0
2	141747	130795	272542	16.8
3	174512	163487	338000	20.8
4	6259	4778	11037	0.7
5	26165	26569	52735	3.2
6	9667	11650	21316	1.3
7	2611	949	3560	0.2
8	10510	10740	21250	1.3
9	342452	319230	661682	40.7
10	62623	23788	86411	5.3
11	5061	6409	11470	0.7
12	7373	5387	12759	0.8
13	16764	116598	133362	8.2
TOTAL	**805785**	**820402**	**1626187**	**100**
GVW/LANE	**49.55**	**50.45**	**100**	**0.01**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0.0213
2	16	13	29	0.2	9e-04
3	56	46	101	0.7	0.0036
4	89	66	154	1.1	0.73
5	229	260	489	3.3	0.26
6	140	166	306	2.1	0.8
7	39	14	54	0.4	1.49
8	94	100	194	1.3	0.52
9	6294	4004	10298	70.2	1.54
10	764	304	1068	7.3	1.17
11	77	115	192	1.3	1.63
12	88	70	158	1.1	1.46
13	301	1315	1616	11	2.01
TOTAL	**8186**	**6473**	**14660**	**100**	**12**
ESALS/LANE	**55.8**	**44.2**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*
Oct 2018	168472	5435	901	140528	83.4	27944	16.6
Nov 2018	159326	5311	1002	129266	81.1	30060.4	18.9
Dec 2018	137277	4576	562	119844	87.3	17433.5	12.7
Jan 2019	136631	4407	857	110055	80.5	26575.5	19.5
Feb 2019	114260	4081	721	94070	82.3	20190.2	17.7
Mar 2019	138776	4477	648	118679	85.5	20096.7	14.5
Apr 2019	140330	4678	641	121113	86.3	19216.6	13.7
May 2019	162937	5174	679	141887	87.1	21050.5	12.9
Jun 2019	156866	5229	642	137597	87.7	19269.2	12.3
Jul 2019	159420	5102	597	140916	88.4	18504.3	11.6
Aug 2019	169242	5447	713	147124	86.9	22117.7	13.1
Sep 2019	152884	5138	780	129490	84.7	23393.9	15.3
TOTAL	**1796421**	**–**	**–**	**1530569**	**–**	**265852**	**–**
AVERAGE	**149702**	**4921**	**729**	**127547**	**85**	**22154**	**15**

###ESALs

Month	*ESALS EB Driving Lane*	*ESALS WB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Oct 2018	9647	10834	20480	2.5
Nov 2018	8223	12550	20773	3
Dec 2018	6326	6234	12560	2.5
Jan 2019	7551	12934	20486	3.3
Feb 2019	7266	8726	15992	3.6
Mar 2019	7505	7468	14973	2.2
Apr 2019	7081	5767	12848	0.6
May 2019	7030	6625	13655	0.7
Jun 2019	14609	11559	26168	1
Jul 2019	7391	4814	12205	1.8
Aug 2019	8503	6385	14889	2.2
Sep 2019	8209	6482	14690	0.9
TOTAL	**99341**	**–**	**–**	**–**
AVERAGE	**8278**	**8365**	**16643**	**2**

###Gross Vehicle Weight

Month	*GVW EB Driving Lane*	*GVW WB Driving Lane*	*Total GVW Kips*
Oct 18	910823	1024892	1935715
Nov 18	876238	1195186	2071423

Dec 18	663511	704078	1367589
Jan 19	748717	1130601	1879318
Feb 19	624281	797364	1421645
Mar 19	705802	775079	1480881
Apr 19	705844	678545	1384390
May 19	771941	774947	1546888
Jun 19	1512692	1451859	2964551
Jul 19	779280	638532	1417812
Aug 19	836256	809778	1646034
Sep 19	806828	821209	1628037
TOTAL	**9942216**	**10802070**	**20744286**
AVERAGE	**828518**	**900173**	**1728690**

###Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Oct 2018	3913	2.3	14	1414	76
Nov 2018	6184	3.9	20.7	2613	60
Dec 2018	1711	1.2	9.6	540	44
Jan 2019	6767	5	25.7	3243	48
Feb 2019	4196	3.8	21.2	1582	67
Mar 2019	2644	1.9	13.3	916	32
Apr 2019	1066	0.8	5.6	213	20
May 2019	1059	0.7	5.1	246	37
Jun 2019	2304	0.7	6	528	106
Jul 2019	1055	0.7	5.9	240	43
Aug 2019	1367	0.8	6.2	229	51
Sep 2019	2137	1.4	9.2	297	55
TOTAL	**34403**	**–**	**–**	**12061**	**639**
AVERAGE	**2866.9**	**1.9**	**11.9**	**1005.1**	**53.2**

###Freight

Month	*EB Freight Tons*	*WB Freight Tons*	*Total Freight*	*EB Freight %*	*WB Freight %*
Oct 2018	107491	153333	260824	41.2	58.8
Nov 2018	93278	223361	316640	29.5	70.5
Dec 2018	71575	83742	155317	46.1	53.9
Jan 2019	81765	228122	309886	26.4	73.6
Feb 2019	80540	135572	216113	37.3	62.7
Mar 2019	86502	104160	190662	45.4	54.6

Apr 2019	86278	71227	157505	54.8	45.2
May 2019	85927	83228	169155	50.8	49.2
Jun 2019	176389	142159	318548	55.4	44.6
Jul 2019	89515	60126	149641	59.8	40.2
Aug 2019	100384	84516	184900	54.3	45.7
Sep 2019	98378	104905	203283	48.4	51.6
TOTAL	**1158022**	**1474451**	**2632473**	**–**	**–**
AVERAGE	**96501.9**	**122870.9**	**219372.8**	**45.8**	**54.2**